



FILTER CLEAR LIMITED

TITLE: SPRUCE DEEP BED FILTER

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A TECHNICAL NOTE TO DESCRIBE THE OPERATIONAL AND PHYSICAL
CHARACTERISTICS OF THE PRESENT MULTI-MEDIA

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Introduction

This invention takes Deep Bed Multi-layered filtration in to a new generation. It relates to the treatment of water, wastewater and brine to eradicate contaminants and disease causing pathogenic micro-organisms, including cryptosporidium and giardia.

It will remove and retain a wider range of particle size than other current designs of deep bed filter. The bar graph (Fig.3) illustrates this point by showing that the filter retains particles in the micron and submicron range, and these test results show overlap in size of the particles retained by the micro-filtration and ultra-filtration processes.

It has many facets for optimal use including those of portable and semi-portable filtration units. For instance either a 4" id or 6" id can be fitted to a Land Rover or similar vehicle and used as a totally mobile unit. A semi-portable system can be housed in a container to facilitate ease of shipment and installation on site with a minimum requirement for engineering services.

This is a high rate filter with a low rate of build-up of head-loss, which gives it significantly longer filter runs between backwashing. Much experimental work has been done on the range of filters up to 2 metres in diameter that gives it a flow rate of 180,000 litres/hour, and this high capacity makes it suitable to provide all sizes of swimming pools. This system would provide a reliable and continuous cover with the benefit of reduced Chlorine requirement.

It is known that some filters have limited application due to their short filter runs between backwashing. Filter runs of less than 24 hours between backwashing are generally inconvenient, as they cause higher operating costs, and are detrimental to works output.

The Spruce Deep Bed Filter has had a wide range of testing with wastewater, high salinity water and brine. As a pre-treatment for Reverse Osmosis its removal rate of sub-micron particles is much higher than the presently used pre-treatment systems. With its well-vetted performance in the clarification of brine and seawater, the filter would be ideal for the removal of impurities, bacteria and micro-organisms from brining systems in the cheese-making process. This system continually filters batches of brine, or permeate is recycled and released back in to a brine pool for re-use.

Because it requires a remarkably low volume of backwash water to clean it, it is particularly suited to applications where reclamation of valuable solids such as those in the electro-plating process, where chemical treatment is not feasible.

Membrane filters are very effective for the removal of particles in the submicron and macromolecular range, but they have a tendency to clog when used to remove particles of a larger size range. However, to minimise this problem, a depth filter such as the 'Spruce' type, should be located upstream of the membrane filter.

The present deep bed filter has the capacity to produce the required specification of feed water, for the futuristic electro-kinetic 'Water Battery'. This battery is powered by water only, and it is required to be non-polluting and non-toxic.

The Multi-Layer Filter Bed

The Spruce multi-layer filter provides a system for the elimination of pathogenic micro-organisms from water and wastewater. The filter bed comprises of four layers of inert particulate material such that, from the top layer (first layer) to the bottom layer (fourth layer), the coarseness of the particulates decreases while the density of the particulate material increased. The particulate materials selected for each layer is required to have a good degree of sphericity. Thus, the shape factor of the particulates in each of the first, second and third layers is desirably at least 0.6 and the shape factor of the particles forming the fourth layer is desirably at least 0.55.

The four discrete layers of biomass support particles employed in the filter-bed form a multi-layer system that provides a very effective external surface for the growth/accumulation of bio species (Fig. 1). Moreover, particle shapes having a high degree of sphericity have advantages associated with ease of fluidisation. In contrast, particles that are significantly or wholly non-spherical create higher-pressure drops within the bed causing discontinuities in the biomass build-up process. Shape factor (which is representative of the degree of sphericity) has been found to be a significant factor in the achievement of a turbulent - free flow regime in the filter-bed and hence a uniform build-up of biomass. A further important advantage of support particles with a consistent shape-factor over non-spherical particles is that bed porosities are lower leading to higher biomass hold-ups.

This multi-layer filter bed has several advantages deriving from its hydraulic stability, which allows a steady-state build-up of accumulated biomass at higher growth-rates. This situation leads to the rapid build-up of accumulated biomass concentration that is much higher than that experienced when using other conventional methods using, for example sand filters. This design of filter has been found to be more efficient in retaining bacteria and parasites than rapid sand filters, particularly because of the formation of a biologically active bed that forms an effective barrier for colloids and particulates even in the submicron range.

The materials forming layers of the filter bed are all porous materials and are selected with regard to their particle size, density and shape factor. In particular, it is important that the settling rate of particulate material in each layer differs from that of the neighbouring layers. Typically the particle size and density are selected so that the settling rate increases by a factor of the order of about 20% from the top layer downwards to the bottom layer.

Hydraulically stable conditions are necessary during reverse flow washing fluidisation of the bed. By selection of the densities and sizes of the materials forming the filter bed, it is possible to ensure that the discrete layered configuration of the bed is substantially restored following backwashing. If necessary, prior to backwashing of the filter-bed, to assist separation of the filter media layers, the bed may be loosened by means of a jet of compressed air.

Once the backwash cycle has been completed, by virtue of characteristics of the materials forming the various layers of the filter-bed, particularly the particle size, density and shape factor characteristics, the filter bed is able to resettle to its original configuration with a limited degree of intermixing of particles at the interfaces between the layers.

In order to support the fine media of the filter-bed formed by layers 1 to 4 and to provide good distribution of air and water during backwashing, it is necessary to have an efficient under drain system. The under drain system for the filter serves a two-fold purpose: to distribute the water uniformly during backwashing and to collect the filtered water without loss of media.

Experimentation has shown that the present multi-layer bed can also be used as an effective biological fluidised-bed reactor. The author of this article prepared a full report on this particular aspect of filter operation.

Filter Performance Tests

The experimental studies have involved testing the capacity of the 'Spruce' filter to retain micro-organisms at filtration rates as high as 15 g.p.m/ft². To simulate this process, filtration tests consisted of filtering a 60ppm w/v suspension of insoluble silica particles having a particle size distribution of ca 4% <0.5 microns and ca 55% <10 microns. These test particles were suspended in potable water at pH's in the range of pH 6.5-7.4.

Throughout these experimental runs, filtrate quality remained between 0.00 and 0.10 NTU which represents 'ultra clear filtrate' containing <0.5 micron particles. Filter runs of 40-50 hours were achieved between backwashing with a build-up of filter head-loss amounting to 3.5-4.5 PSIG (Fig.4).

Progressive clogging of the filter takes place due to locally altered geometry and hydrodynamic conditions in the filter pores. When the filter head-loss reached about 7.0 PSIG, the onset of particle breakthrough occurred followed by a progressive deterioration in filtrate quality.

To provide further evidence of the capacity of the filter to retain particles of sub-micron size, a 20-hour continuous test with a suspension of surrogate cryptosporidium showed that the filter had retained 99.954% - 99.974% of particle counts down to 0.2 microns without the assistance of either a coagulant or coagulant aid. Throughout this experimental run, a low turbidity filtrate of 0.00 (nil) - 0.10 NTU was maintained.

The customary economic backwash requirement of less than 1% of the volume of filtrate produced during the filtration cycle was found to be adequate to clean the filter.

Until now, it has been presumed that only membrane filters with all their faults and cost, could produce a stable sustained commercial output. Now Spruce has designed a range of deep bed filters, which will give outputs of 500 litres per hour with a 9cm diameter filter bed to 180,000 litre/hr with a 2.0 metre diameter filter bed. Filter tests have shown that the present system has a reliable and unsurpassed pathogen removal ability that substantially increases its medical and ethical uses.

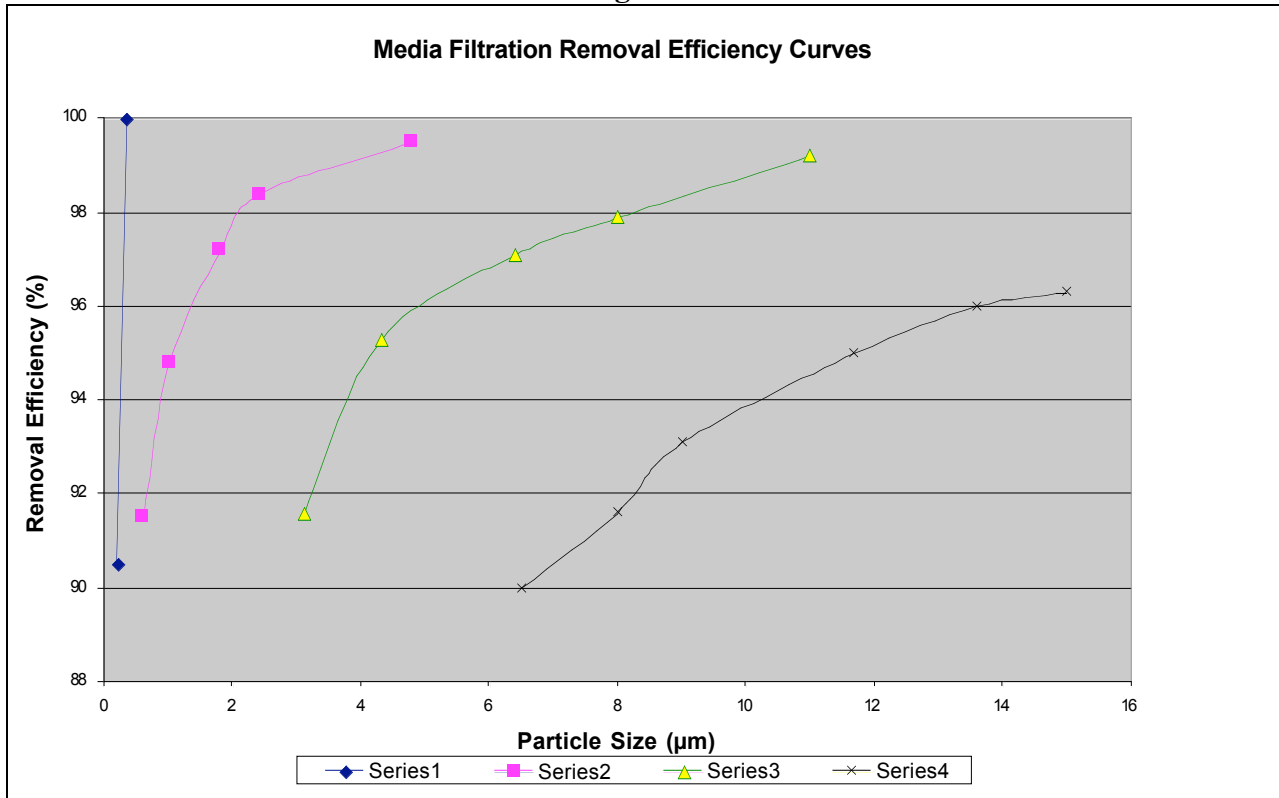
The multi-media filter unit as described in this technical note may be up to 2 metres in diameter and can be operated at filtration rates in the range of 10-15 gpm/ft² at 10⁰C and as high as 20-25 gpm/ft² when the water temperature is raised to 30⁰C. By direct comparison, the highest filtration rate attained by the latest design of rapid sand filter is only about 5 gpm/ft². The filter unit can typically clarify suspensions up to contaminant concentrations of 500 mg/litre while giving a final filtrate quality of less than 0.5 NTU. Internationally, this result is classified as 'ultra-clear', and known to represent a particle removal efficiency of better than 99% removal of pathogens down to 0.2 microns.

The higher filtration rates and longer filter runs that can be obtained with a multi-media filter unit as described herein provide a substantial saving of capital expenditure on new plant and, by comparison with a conventional sand filter, there is a large reduction in volume of wash water required to clean the filter-bed. Additionally, the bed design allows very effective backwashing such that the volume of water used for adequate backwashing may be of the order of 0.5-1% of the volume of filtrate obtained during a filtration cycle.

The Spruce filtration process is patented.

It is clear that the removal of pathogenic micro-organisms by coagulation, clarification and filtration depends on optimising these treatment processes.

Figure 2



Series	Type of Filter
1	Spruce Deep Bed Filter – 4 Layers of Media – Rate: 15 GPM/ FT ²
2	Filter With 3 Layers of Media – Rate: 15 GPM/ FT ²
3	Filter With 2 Layers of Media – Rate: 10 GPM/ FT ²
4	Conventional Sand Filter – Rate: 3 GPM/ FT ²

Figure 3. Range of Particle Size Retained by Each Filtration Process.

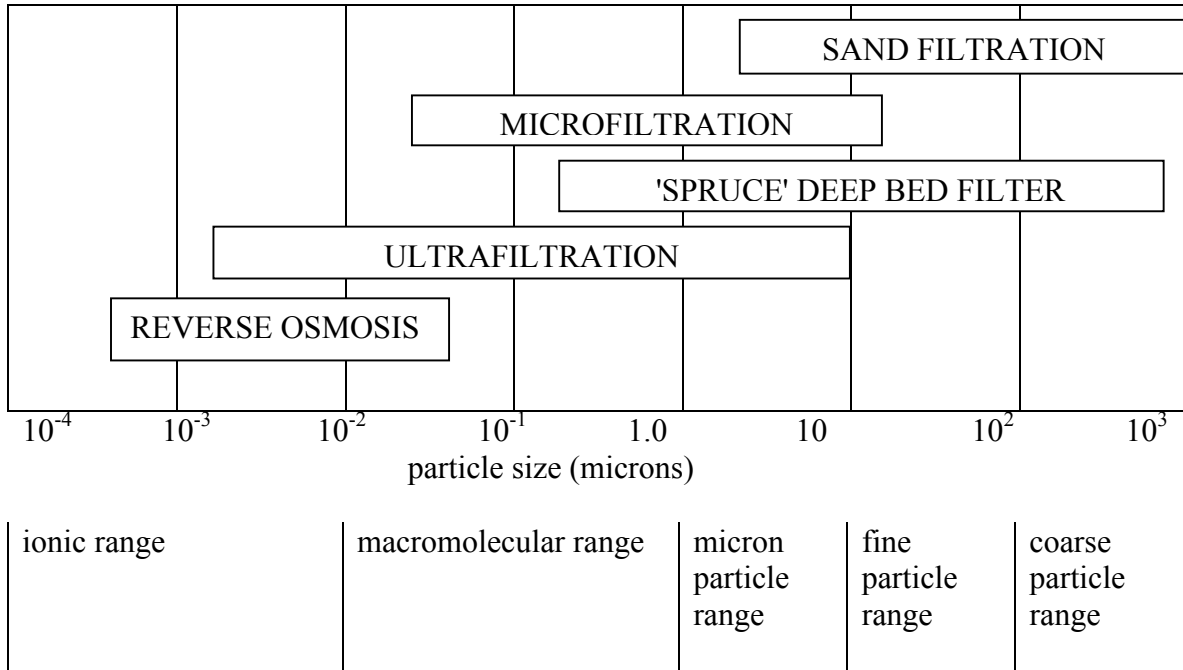


Figure 4. Rate of Build-up of Head-loss in a Spruce Deep Bed Filter.

